BUNDESREPUBLIK DEUTSCHLAND

Prioritätsbescheinigung
DE 102 20 961.8
über die Einreichung einer Patentanmeldung

Aktenzeichen:	102 20 961.8
Anmeldetag:	02. Mai 2002
Anmelder/Inhaber:	Heinrich-Hertz-Institut für Nachrichtentechnik Berlin GmbH, 10587 Berlin/DE
Bezeichnung:	Verfahren und Anordnung zur Kodierung von Transformations-Koeffizienten in Bild- und/oder Videokodierern und -dekodierern sowie ein entsprechendes Computerprogrammprodukt und ein entsprechendes computerlesbares Speichermedium
IPC:	H 04 N 7/24, H 04 N 7/30

Die angehefteten Stücke sind eine richtige und genaue Wiedergabe der am 02. Mai 2002 eingereichten Unterlagen dieser Patentanmeldung, hinterlegt mit dem Prioritätsbeleg vom 30. Mai 2003 bei der World Intellectual Property Organization.

München, den 25. Januar 2010
Deutsches Patent- und Markenamt
Die Präsidentin
Im Auftrag

A 4

Verfahren und Anordnung zur Kodierung von Transformations-Koeffizienten in Bild- und/oder Videokodierern und -dekodierern sowie ein entsprechendes Computerprogrammprodukt und ein entsprechendes computerlesbares Speichermedium

Beschreibung

Die Erfindung betrifft ein Verfahren und eine Anordnung zur Kodierung von Transformations-Koeffizienten in Bild- und/oder Videokodierern und -dekodierern sowie ein entsprechendes Computerprogrammprodukt und ein entsprechendes computerlesbares Speichermedium, welche insbesondere bei der digitalen Datenkompression eingesetzt werden kann.

Besonderes Kennzeichen der Erfindung ist, daß für alle Blöcke von Transformationskoeffizienten, einschließlich dem Luminanz-Block für den INTRA-4x4-Mode, ein einziger einfacher Scan-Vorgang durchgeführt wird wobei die Syntax-Elemente COEFF_COUNT und RUN hierbei durch ein Ein-bit-Symbol CBP4 und eine Signifikanz-Abbildung ersetzt werden. Die einzelnen Levels werden in umgekehrter Reihenfolge gescannt. Die Kontext-Modellierung erfolgt in neuer Weise.

Improved Coding of Transform Coefficients with CABAC

Heiko Schwarz, Detlev Marpe, and Thomas Wiegand

We propose a new scheme for the coding of transform coefficients with CABAC, which further improves the coding efficiency compared to the CABAC version of the current working draft [1], especially for INTRA-frames. The differences to the current CABAC version can be summarized as follows:

- The simple single scan is used for all blocks of transform coefficients including the luminance blocks for the INTRA-4x4 mode,
- The syntax elements COEFF_COUNT and RUN are replaced by a one-bit symbol CBP4 and a significance map.
- The levels are encoded in reverse scanning order.
- The context modeling is changed for all syntax elements concerning transform coefficient encoding.

Figure 1 illustrates the new coding scheme. A one-bit symbol called CBP4 is transmitted first for each block of transform coefficients unless the CBP indicates that the regarded block has no non-zero coefficients. This CBP4 symbol is one if there are any significant coefficients inside the block. If it is zero, no further information is transmitted for the block; otherwise a significance map specifying the positions of significant coefficients is encoded. Afterwards, the absolute value as well as the sign is encoded for each significant transform coefficient. These values are transmitted in reverse scanning order. A more detailed description of the encoding process is given in section 1.1. In section 1.2, the context modeling is discussed.

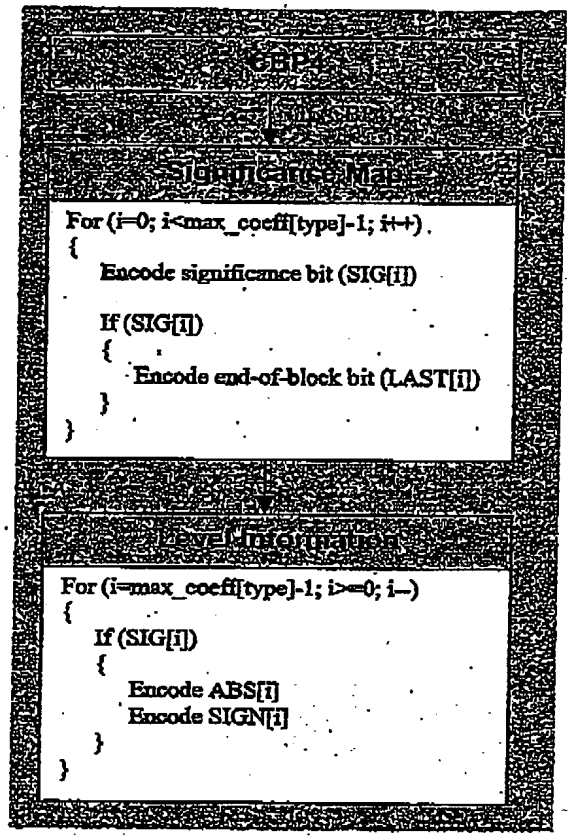

Figure 1: Proposed scheme for encoding of transform coefficients

1.1 Description of the coefficient encoding process

1.1.1 Scanning of transform coefficients

In contrast to the working draft Number 2 [1], where a double scan is used for transmitting the luminance block coded in INTRA-4x4 mode, we propose to use the simple single scan (zig-zag scan) for all block types including the luminance blocks coded in INTRA-4x4 mode.

1.1.2 CBP4

CBP4 is a one-bit symbol, which indicates if there are significant (non-zero) coefficients inside the regarded block of transform coefficients. If the CBP4 is zero, no further information is transmitted for the block.

1.1.3 Significance map

If the CBP4 indicates that a block has significant coefficients, a significance map is encoded. For each coefficient in scanning order, a one-bit symbol (SIG) is transmitted. If the SIG symbol is one, that is if a non-zero coefficient exists at this scanning position, a further one-bit symbol (LAST) is sent. This symbol indicates if the current significant coefficient is the last one inside the block or if further significant coefficients follow. Figure 2 shows two examples for the proposed significance map encoding. The significance information (SIG, LAST) for the last scanning position of a block is never transmitted. If the last scanning position is reached and the significance map encoding was not already terminated by a LAST-symbol of one, it is obvious that the last coefficient has to be significant (see yellow marked position in Figure 2).

Coefficients										
SIG	1	0	1	1	0	0	1	0	1	
LAST	0		0	0			0		1	

Coefficients																
SIG	1	1	0	0	0	1	1	1	0	0	0	0	1	0	0	
LAST	0	0				0	0	0					0			

Figure 2: Two examples for encoding the significance map (the yellow marked symbols are not transmitted)

1.1.4 Level Information

The encoded significance map determines the positions of all significant coefficients inside a block of quantized transform coefficients. The values of the significant coefficients (levels) are encoded by two coding symbols: ABS (representing the absolute value), and SIGN (representing the sign). While SIGN is a one-bit symbol (1 for negative coefficients), a unary binarization scheme (see Table 1) is used for encoding the absolute values of the coefficients. The levels are transmitted in reverse scanning order (beginning with the last significant coefficient of the block); this allows the usage of more reasonable contexts.

Table 1: Unary binarization for absolute values of quantized transform coefficients (ABS)

ABS	Unary Binarization						
1	0						
2	1	0					
3	1	1	0				
4	1	1	1	0			
5	1	1	1	1	0		
6	1	1	1	1	1	0	
7	1	1	1	1	1	1	0
...	...	...	...	...	...	...	...
bin	1	2	3	4	5	6	7 ...

1.2 Context determination

In JVT coding, there are 12 different types of transform coefficient blocks with different statistics of transform coefficients (left column of Table 2). However, for most sequences and coding conditions some of the statistics are very similar. To keep the number of contexts used for coefficient coding reasonably small, the block types are classified into 5 categories as specified in the right column of Table 2). For each of these categories, a special set of contexts is used.

Table 2: Basic block types with number of coefficients and context types

Block type	# Coeffs	ctxBlockCat
Luminance DC block for INTRA16x16 mode	16	0: Luma-Intra16-DC
Luminance AC block for INTRA16x16 mode	15	1: Luma-Intra16-AC
Luminance block for INTRA 4x4 mode	16	2: Luma-4x4
Luminance block for INTER mode	16	
U-Chrominance DC block for INTRA mode	4	3: Chroma-DC
V-Chrominance DC block for INTRA mode	4	
U-Chrominance DC block for INTER mode	4	
V-Chrominance DC block for INTER mode	4	
U-Chrominance AC block for INTRA mode	15	4: Chroma-AC
V-Chrominance AC block for INTRA mode	15	
U-Chrominance AC block for INTER mode	15	
V-Chrominance AC block for INTER mode	15	

1.2.1 Context determination for CBP4

For encoding the CBP4 bit, four different contexts are used for each of the five categories specified in Table 2. The context number for the current block C is determined by

$$ctx\_number\_cbp4\ (C) = CBP4\ (A) + 2 \times CBP4\ (B),$$

where A and B represent the corresponding blocks of the same type to the left and on the top of the regarded block C (see Figure 3). Only blocks of the same type (left column of Table 2) are used for context determination. If a neighboring block X (A or B) is positioned in a different slice, or if no neighboring block X of the same type exist (e.g. because the current block in INTRA-coded while the neighboring block X is INTER-coded), the corresponding CBP4(X) value is replaced by a default value. If the current block is coded in an INTRA-mode, a default value of 1 is used; otherwise, a default value of 0 is used. So, while all twelve block types (left column of Table 2) are distinguished for determining the context number, only five different sets of contexts (each for one category specified in the right column of Table 2) are used for encoding the CBP4 symbol. This results a total number of 20 contexts for the CBP4 bit.

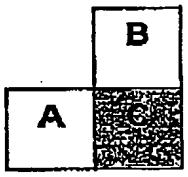

Figure 3: Context determination for CBP4

1.2.2 Context determination for significance map encoding

For encoding the significance map, up to 15 contexts (depending on the block type category) are used for both the SIG and the LAST symbols. The context numbers are given by the corresponding scanning position, i.e. for a coefficient *coeff[i]*, which is scanned at the i-th position, the contexts are chosen as follows:

ctx_number_sig (coeff[i]) = ctx_number_last (coeff[i]) = i.

For each category of block types, we use *number_of_coefficients-1* different contexts. This gives a total number of 61 contexts for both the SIG and the LAST symbol.

1.2.3 Context determination for level encoding

The absolute value of the significant coefficients is encoded using the uniform binarization depicted in Table 1. Here we use two different sets of contexts, one for the first bin (marked orange in Table 1), and another one for all remaining bins of the binarization:

ctx_number_abs_1bit = (coeff>1 transmitted ? 4 : max (3, number of coeff=1 transmitted))

ctx_number_abs_rbits = max (4, number of coeff>1 transmitted)

The level information is transmitted in reverse scanning order. The context for the first bin of the absolute values is determined by the number of successive coefficients (in reverse scanning order), which have an absolute value of 1. If more than three coefficients have an absolute value of 1, context 3 is always chosen. When a coefficient with an absolute value greater 1 is encoded, context 4 is used for all remaining coefficients of the regarded block.
All remaining bins of the absolute value are encoded using the same context. It is determined by the number of transmitted coefficients with an absolute value greater

1 (in reverse scanning order) with a maximum context number of 4. Figure 4 shows two examples of the context determination for encoding the absolute value of significant coefficients.

Coefficients	4	0	5	3	0	0	1	0	1							
ctx_number_abs_1bit	4		4	2			1		0							
ctx_number_abs_rbits	2		1	0												

Coefficients	10	2	1	6	4	5	1	1	0	1	0	0	0	0	1	
ctx_number_abs_1bit	4	4	4	4	4	3	3	3		2		1				0
ctx_number_abs_rbits	4	3		2	1	0										

Figure 4: Examples of context determination for encoding the absolute value of significant coefficients. The level information is transmitted in reverse scanning order.

For the sign of significant coefficients, just one context is used per category of block types. Thus the total number of contexts for encoding the level information is 54 (for the chroma DC blocks, there are only 4 different contexts for the "remaining" bits of the absolute value, since at maximum 4 coefficients are transmitted).

References

[1] Wiegand, Sullivan, "Working Draft Number 2", JVT-B118r7, April 2002.

Patentansprüche

1. Verfahren zur Kodierung von Transformations-Koeffizienten in Bild- und/oder Videokodierern und -dekodierern,

dadurch gekennzeichnet, dass

für alle Blöcke von Transformationskoeffizienten ein einziger einfacher Scan-Vorgang durchgeführt wird wobei die Syntax-Elemente COEFF_COUNT und RUN hierbei durch ein Ein-bit-Symbol CBP4 und eine Signifikanz-Abbildung ersetzt werden.

2. Verfahren wie in Anspruch 1, bei dem zusätzlich für die Kodierung bzw. Dekodierung des Ein-bit-Symbols CBP4 und der Syntaxe-Elmente LEVEL eine kontext-basierte Kodierung bzw. Dekodierung vorgenommen wird.

3. Anordnung mit mindestens einem Prozessor, der (die) derart eingerichtet ist (sind), dass ein Verfahren zur Kodierung von Transformations-Koeffizienten in Bild- und/oder Videokodierern und -dekodierern gemäß Anspruch 1 durchführbar ist.

4. Computerprogramm-Erzeugnis, dass ein computerlesbares Speichermedium umfasst, auf dem ein Programm gespeichert ist, das es einem Computer ermöglicht, nachdem es in den Speicher des Computers geladen worden ist, ein Verfahren zur Kodierung von

Transformations-Koeffizienten in Bild- und/oder Videokodierern und -dekodierern gemäß Anspruch 1 durchzuführen.

4. Computerlesbares Speichermedium, auf dem ein Programm gespeichert ist, das es einem Computer ermöglicht, nachdem es in den Speicher des Computers geladen worden ist, ein Verfahren zur Kodierung von Transformations-Koeffizienten in Bild- und/oder Videokodierern und -dekodierern gemäß Anspruch 1 durchzuführen.

Zusammenfassung

Die Erfindung betrifft ein Verfahren und eine Anordnung zur Kodierung von Transformations-Koeffizienten in Bild- und/oder Videokodierern und -dekodierern sowie ein entsprechendes Computerprogrammprodukt und ein entsprechendes computerlesbares Speichermedium, welche insbesondere bei der digitalen Datenkompression eingesetzt werden kann.

Hierzu wird vorgeschlagen, daß für alle Blöcke von Transformationskoeffizienten ein einziger einfacher Scan-Vorgang durchgeführt wird wobei die Syntax-Elemente COEFF_COUNT und RUN hierbei durch ein Einbit-Symbol CBP4 und eine Signifikanz-Abbildung ersetzt werden.